Passive Solar Heating & Cooling

Vermont's one-room schoolhouses were an early example of how buildings were oriented to the south to take advantage of "passive" solar heating and daylighting. With today's new window technology and insulation products, the sun can provide 30 to 50 percent of a building's heating and lighting needs, using only passive solar and daylighting techniques. Because this can be done on a budget only 10 to 20 percent more than conventional construction, proven passive solar strategies should be incorporated into new buildings and remodeling projects.

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Passive Principles

Passive solar heating systems rely on a building's orientation, windows and the mass of its floors and walls to capture and store solar energy. *Active solar systems* use special collectors, pumps, fans and controls to collect the sun's energy. While passive systems rely primarily on the natural flow of energy and air through a building, many will incorporate a few active components such as a small thermostatically controlled fan to assist in the distribution of solar energy.

Passive solar buildings are designed around three main principles:

- Maximizing energy-efficiency of the building envelope
- Achieving useful solar gain for heating and daylighting
- Using floors and walls with a large *thermal mass* (heat storage ability) to store and slowly release solar energy to minimize temperature swings

By first investing in better wall and ceiling insulation, better doors and windows, more useful solar energy can be retained in the

house. Many solar houses are *superinsulated*, meaning they have up to twice the insulation of a conventional home. This improves solar gain and elevates comfort levels.

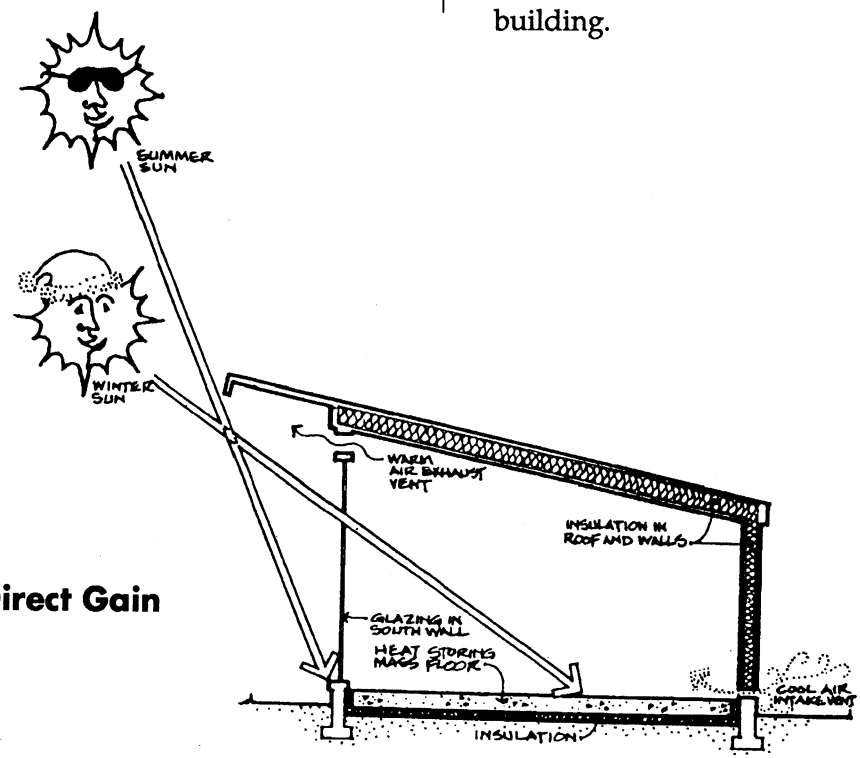
Passive Heating Techniques

The four basic ways passive solar heating can be incorporated into building design are briefly explained below. These four techniques are discussed in more detail in a publication entitled, *Passive Solar Design Strategies: Guidelines for Homebuilders*, which is available at cost from the Vermont Department of Public Service. Computer software for the design guidelines is also available.

Suntempering. Uses a good southern building orientation, the existing mass of the house and a modest increase in the amount of south-facing glass to increase solar gain and thereby reduce energy bills. For Vermont, the rule of thumb is that the south-facing glass of a building can equal seven percent of the total floor area of the house without adding extra thermal mass to prevent overheating. It also makes sense to minimize glass on the other sides of the building, particularly the north and west. This will result in a 5 to 10 percent energy savings and requires almost no additional expense.

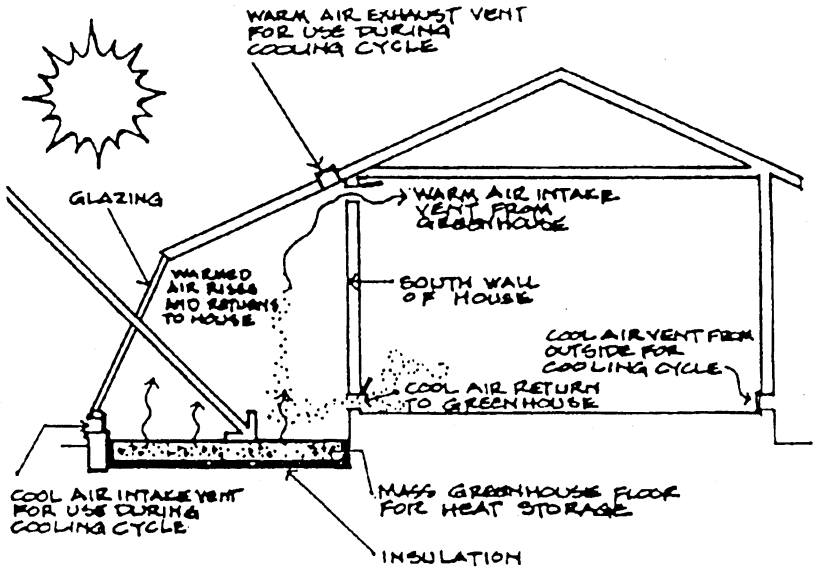
Direct Gain. Uses south-facing glass with additional thermal storage for greater solar gain. Up to twice as much south-facing glass (12 percent of total floor area) can be used effectively if there is a mass floor or wall that can capture and store the thermal energy. Thermal mass floors are typically well insulated, 6-inch concrete slabs that have a colored surface or are covered with brick or dark tile. Thermal mass walls can be made of concrete blocks, bricks or water tubes.

The most useful type of mass floor or wall is one that is directly in the sun. This is seven times more effective at absorbing and storing solar energy than "remote" mass that is not sunlit. In Vermont, direct gain systems can provide 15 to 25 percent of the heat needed for a well insulated building.



Direct Gain

Sunspace



Sunspaces. One of the most widely used and cost-effective passive strategies in Vermont is the sunspace. This consists of either an add-on or integrated solar room on the south side of a house. On warm, sunny days this room is opened to the house, allowing solar heated air to circulate. At night it can be closed off from the main house to minimize heat loss through the windows. Like other direct gain systems, sunspaces should have a thermal storage floor or wall to minimize temperature swings and to keep the sunspace above freezing when closed off at night.

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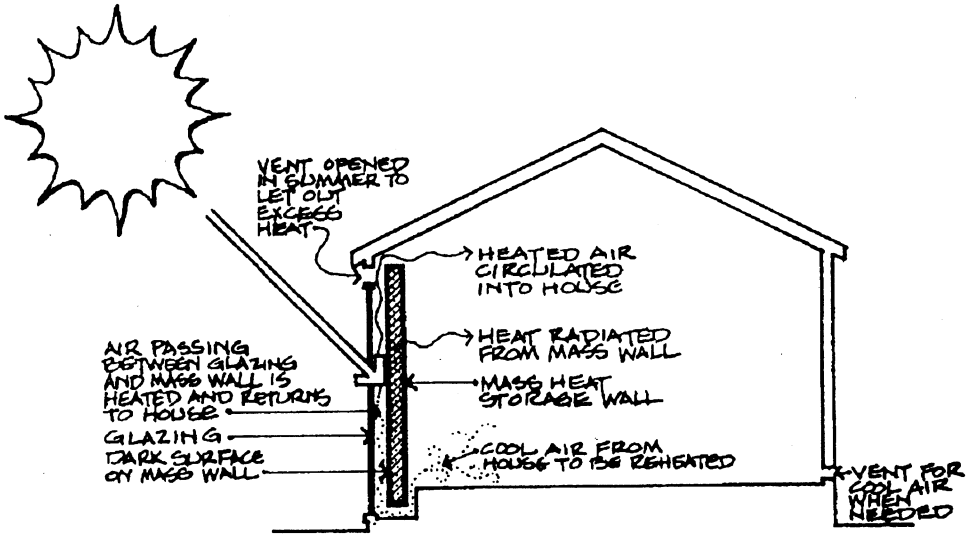
A well-designed sunspace can provide 20 to 30 percent of a building's heat and provide a pleasant space for enjoying the sun during the cold winter months. Sunspaces can also be used as greenhouses, but this reduces energy gain because the sunspace temperature must be kept within narrower limits for plant growth and may require supplemental heat.

Trombe Wall. This type of passive system uses a heat-storing, opaque *mass wall* directly behind south-facing glass to absorb the sun's energy during the day and then radiates the heat into the living area at night. Trombe walls are usually built of 12-inch thick concrete or masonry that is directly behind 4' x 8' sheets of solar (low-iron) glass. The outer wall surface is covered with a special black *selective coating* on the south side. This painted coating increases solar absorption and decreases the amount of energy the wall surface loses through the outer glass.



Trombe Wall

An important benefit of a Trombe (pronounced TROM) wall is that energy gained during a sunny day is not immediately transferred to the living space but is stored and then slowly released at night. This prevents the house from overheating during the day when direct gain windows are also collecting energy. A drawback of such mass walls is that they block any view and natural daylight in that wall section.

Combined with some direct gain windows, a mass wall system can increase a home's solar fraction substantially and help deliver solar energy both day and night. In Vermont, a mass wall and direct gain system can provide 30 to 40 percent of a building's heating needs.

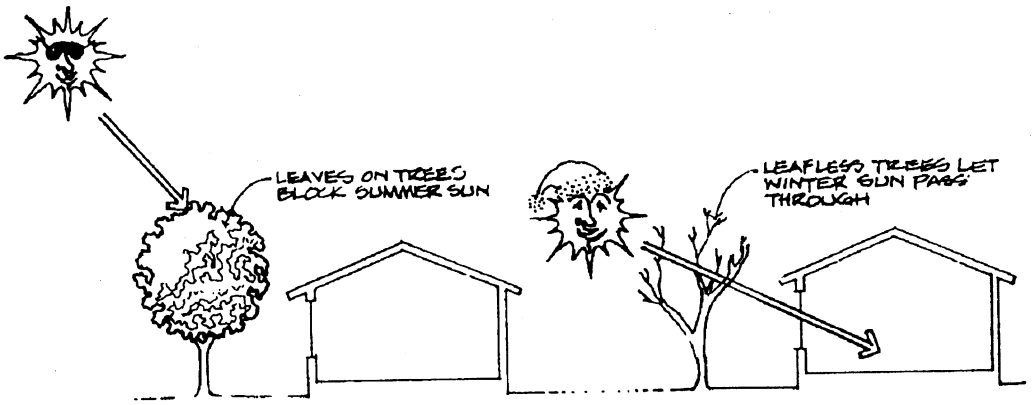
Passive Cooling Techniques

Although Vermont summers are typically short and cool, there are still three months of the year when some cooling energy is needed in most homes. Proper passive cooling techniques can eliminate the need for most air conditioning.

Insulation. Just as well-insulated walls, ceilings and foundations are key to keeping heat in during the winter, they also serve to keep out unwanted heat in the summer. Adequate attic ventilation also holds down interior heat gain on sunny summer days.

Window Orientation. Minimizing west-facing windows (which receive the full force of the summer afternoon sun) and unshaded roof skylights minimizes summer solar gain. Both of these window orientations receive little useful solar energy during the winter but get a tremendous amount on hot summer days.

Shading. Deciduous trees planted to the south and west of a house can help shade windows in the summer but allow solar gain in the winter. Properly sized roof overhangs or moveable awnings on the south wall can also help shade windows from the summer sun, which is high overhead, while

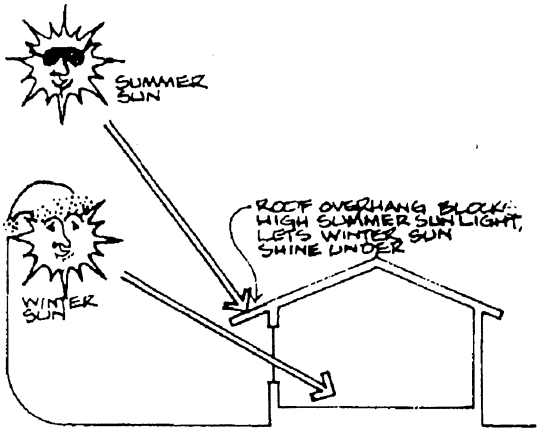


Shading

allowing the winter sun's rays to penetrate the windows.

Some passive solar buildings make use of eave trellises that are used to grow large leafed vines in the summer. This gives maximum shading in July and August when it is needed most and produces a wonderful quality of light on the south side of a building.

Night Ventilation. Because Vermont enjoys warm days and cool nights during most of the summer, nighttime "whole house" ventilation is very effective. Just opening windows or using an attic fan to draw cool night air through the house will remove excess heat that was gained during the day. If a home has enough thermal mass, heat gained during the day will not raise the interior temperature appreciably and ventilation at night will then cool the thermal mass. For this strategy to work effectively, it is important that the windows and doors remain closed during the day.



Shading